STANDARDS DEVELOPMENT BRANCH OMOE
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EVALUATION OF "AQUAROBIC" SEWAGE TREATMENT SYSTEM

interim report
july, 1973

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Ontario

Ministry
of the
Environment

The Honourable
William G. Newman,
Minister

Everett Biggs,
Deputy Minister

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PRIVATE WASTE AND WATER MANAGEMENT BRANCH

TECHNICAL SERVICES

Evaluation of "Aquarobic"
Sewage Treatment System

Period: September 1972 to April 1973

The "Aquarobic" Waltec sewage treatment system (see attached sketch A and Appendix 1) has been under evaluation at the Ontario Research Foundation since September 5, 1972. The raw sewage flow to the system from September 5, 1972 to January 11. 1973 was 255 U.S. g.p.d. (212 I. g.p.d.). On January 12, 1973, the flow was increased to 400 U.S. g.p.d. (333 I. g.p.d.).

This report covers the first seven months of the total twelve-month test period which ends in September 1973. A final evaluation will then be made, incorporating the results of field test installations now underway.

The blower and the sludge return mechanism operated without problems for the six-month period. On November 27, 1972, it was, however, observed that all the air was going into one part of the reactor. This was rectified by the installation of an air stream splitter.

Hydraulic (37 Imp. gallons) and biological (300 gm of skim milk powder) shock load tests were performed on December 14 and December 18 respectively when the unit was operating at 212 I. g.p.d. The samples tested for BOD and suspended solids in the effluent from the system did not show any significantly abnormal values.

Daily twenty-four hour composite samples were taken, and tested for BOD, suspended solids, volatile suspended solids, nitrate and phosphate from September 5, 1972 to April 28, 1973.

Daily twenty-four hour composite samples were taken and tested for total and soluble organic carbon from September 5, 1972 to February 5, 1973 and then discontinued.

Weekly twenty-four hour composite samples were taken and tested for ammonia, total Kjeldahl as nitrogen, nitrite, total and faecal coliform from September 5, 1972 to April 28, 1973.

The number of samples tested for each individual parameter are shown in Appendix 3.

After operating the unit at 333 I. g.p.d. for about a month, a shock load consisting of 37 Imp. gallons of tap water and 2/3 cup of household detergent was applied on January 9, 1973. The BOD in the sample from the unit (OUT 1) after 30 minutes showed an increase from 18.6 to 36.2 mg/l and 82.5 mg/l after 60 minutes. The corresponding values for suspended solids in the two samples were 87.0 and 495.0 mg/l. The unit later started recovering and the values came to normal after approximately two hours.

Another similar shock load test was performed on February 20, 1973. The BOD values in the unit (OUT 1) showed an increase after 75 to 90 minutes. The values were 89.0 and 72.0 mg/l respectively. The suspended solids, however, reached a value of 1,741 mg/l within 15 minutes. After 45 minutes, these were 1,488 mg/l and then decreased to 832 and 196 mg/l in the samples collected after 60 and 75 minutes respectively. The reactor returned to normal operation after about 2½ hours. There appeared to be no increase in BOD during this shock test period in the samples from the sand filter effluent (OUT 2) though the suspended solids had increased from 13.6 to 36.8 mg/l between 15 and 30 minutes. This value was reduced to 11.6 mg/l in the 60 minute sample and continued to decrease until the system returned to normal in approximately three hours.

On February 9, 1973, a water heater was installed in the reactor. This increased the temperature of the liquid from 8°C to 20°C and simultaneously upset the operation of the unit. The values of BOD and suspended solids from the reactor increased to 44.5+ and 200 mg/l respectively. The heater broke down on February 14, 1973 and was not returned to service. Apparently the change in climate of the reactor disturbed the biological action for almost a week.

The values of the effluent from the unit (OUT 1) for BOD between February 27, 1973 and March 2, 1973 were in the range of 70 to 173 mg/l. The values for suspended solids during the same period were 347 to 668 mg/l. The dissolved oxygen tests conducted occasionally once a day indicated dissolved oxygen in the reactor of more than 4 mg/l. However, while continuously monitoring the amount of dissolved oxygen in the reactor it was observed that at one stage, on several days the dissolved oxygen approached zero. Consequently, Waltec installed new type of aerators on March 6, 1973, which apparently eliminated that problem. Regular Service Calls for the maintenance of the installation were made on December 5, 1972 and March 5, 1973.

The laboratory data collected on the influent and the effluent from the unit (OUT 1) and the filter (OUT 2) was analysed as follows.

Method of Analysis:

The data is first arranged in ascending order of magnitude. Next, the individual numbers are given a ranking, starting with the smallest. Finally, the plotting position for each of the numbers is determined by dividing its ranking by the total number of numbers plus one (N + 1) and multiplying by 100 to convert to a percent. Each number is then plotted on probability paper. A straight line is obtained for data which approximate a normal distribution. The 15%, 50% and 85% of time values are then obtained from the graph.

A computer program (Fortran) was written for such analysis. The program first arranges the data in ascending order and the percent for each datum is calculated as mentioned. It then converts the data to logarithm values and the percentages to probit values. For a normal distribution, the logarithm value is a linear function of the probit value. This was obtained by means of the 'least square fit' method. The corresponding logarithm values for the 15%, 50% and 85% are then calculated and converted back to antilogarithm values, which are then printed out by the computer.

The program is also designed to eliminate the highest and lowest values in turn and the whole procedure is repeated after each elimination. The execution of the program stops after 1/10 of the data have been eliminated.

The data obtained were coded for each individual parameter and keypunched by the Ministry of the Environment staff. The data cards, together with the "source deck" were then submitted to Electronic Computing Branch of the Ministry of Transportation and Communications, where the whole job was run in the computer.

Parameters with less than 30 observations were analysed by the graphical method instead of the computer method.

The values for 15%, 50% and 85% of the time at the two sewage loading rates are given in Appendix 2. The values for minimum and maximum for each parameter are shown in Appendix 3.

The statistical analysis of the results indicate that the unit (OUT 1) at sewage rate of 212 I. g.p.d. produced an effluent with BOD and suspended solids for 85% of the time equal to or less than 25.6 and 41.2 mg/l respectively. These exceed more than 10% of the time the maximum values given in the National Sanitation Foundation Standard 40 for the classification as Class I System. The corresponding values for the effluent from the filter (OUT 2), however, were 5.2 and 9.5 mg/l respectively.

The phosphate reduction in the unit (OUT 1) was approximately 20% or less and there was further 16% reduction through the sand filter (OUT 2) giving an overall reduction of approximately 36% (212 I. g.p.d.).

At the rate of 333 I. g.p.d., the values for BOD and suspended solids from the unit (OUT 1) for at least 15% of the time were greater than 62 and 127 mg/l respectively. The National Sanitation Foundation Standard 40 for units requires that the values for BOD and suspended solids of 60 or 100 mg/l should not be exceeded for more than 10% of the time to be classified as a Class II System.

The phosphate reduction through the unit (OUT 1) was approximately 6% and through the filter (OUT 2) 30%. The overall reduction was 36% and the final effluent contained phosphate equal to or less than 23.5 mg/l (PO_4) in 85% of the samples (333 I. g.p.d.).

The values of free ammonia in the effluent continued to decrease with almost nil quite often from the middle of March 1973.

Single organic and hydraulic shock load upset the unit for two to three hours as observed from the values of BOD and suspended solids when operating at 333 I. g.p.d. The sand filter, however, absorbed the shock to a great extent. It is, however, too early to predict the useful life of the filter at this loading rate.

The system consisting of the unit and the sand filter as a whole produced an effluent 85% of the time with BOD and suspended solid values of equal to or less than 6 and 13 mg/l respectively. The unit itself, however, showed better efficiency at the sewage loading rate of 212 I. g.p.d. than at 333 I. g.p.d.

A comparison was made of the results of removals of BOD, suspended solids and phosphorus in Ministry operated municipal extended aeration plants and the Waltec aquarobic and these are shown in Appendices 4, 5 and 6.

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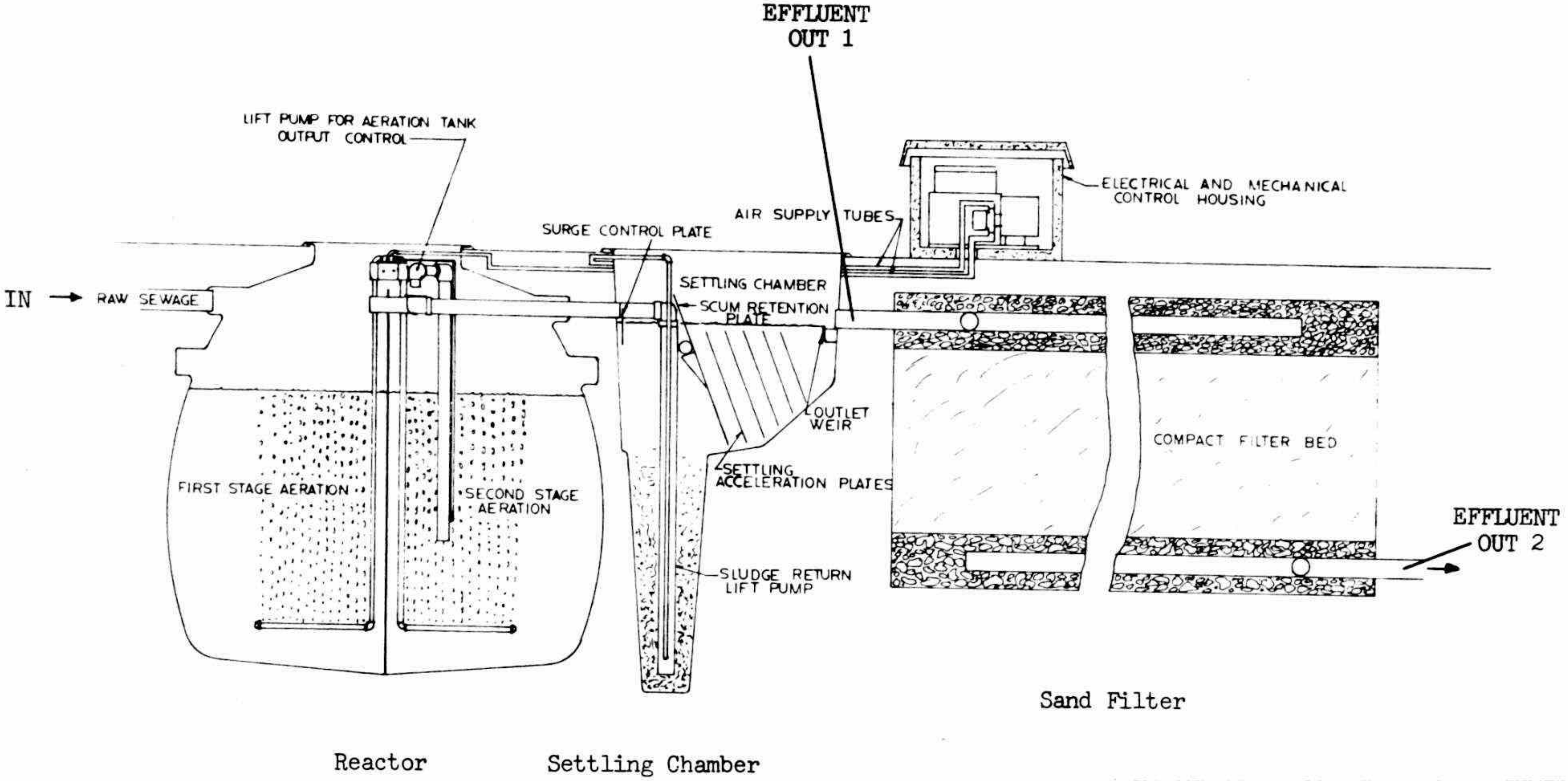

Ministry of the Environment

Private Waste and Water Management Branch

Aquarobic Waltec Sewage Treatment System

Sketch A

PRIVATE WASTE AND WATER MANAGEMENT BRANCH

TECHNICAL SERVICES

"Aquarobic"

Design Details

The "Aquarobic" is an aerobic sewage treatment system for individual homes developed by Waltec Industries Limited, Wallaceburg. The system essentially consists of an aeration tank, settling chamber and a sand filter.

Raw sewage enters the aeration tank where it comes in contact with air being injected through air diffusers. The aeration tank is divided into two compartments to ensure complete mixing and aeration of the waste water.

The mixed liquid is transferred through an air lift pump to the settling chamber. The lift pump controls the level of the waste and output from the tank discharging into the settling chamber. The sludge solids settle to the bottom and the supernant flows out to the sand filter. The sludge is periodically returned to the first aeration compartment.

Specifications given by Waltec for their equipment are:

Number of persons serviced	up to 8
Daily design flows - Imperial Gallons	up to 400
BOD_5 capacity - pounds per day	up to 1.36
Aeration tank capacity - Imperial Gallons	600

Settling tank capacity - Imperial Gallons	90
Blower capacity, cu. ft. per minute	6.5

The other data calculated from these specifications is as follows:

1. BOD loading rate

BOD loading per person = 0.17 lbs/c/day

for six persons = 0.17 x 6 = 1.02 lbs/day

loading rate $= \frac{1.02}{95} = 0.01$ lbs BOD/ ft^3

2. Daily design flow = 400 gallons (Imperial)

3. Aeration Tank

Capacity of tank = 600 gallons (Imperial)

M.L.S.S. in tank = 640 to 820 mg/l (O.R.F. reports)

Retention time in tank $= \frac{600 \times 24}{400} = 36$ hours

4. Air Requirement

The air blower is rated at 6.5 cubic feet/min.

Air supply to lift pump for aeration tank outlet control

= 1 to 1.5 cubic ft/min

Air supply for aeration = 5 cubic ft/min

= 7,200 cubic ft/day

Theoretical amount of air required for treating 400 gallons of waste with B.O.D. of 300 mg/l = 1350 ft^3/day.

Waltec have designed on the basis of 3,200 cubic ft/day to allow for total oxidation and nitrification (J. Forgie).

5. Settling Chamber

Settling chamber area = 2.5 x 3 sq. ft.

Effective surface area = 7.5 x 2/3 = 5 sq. ft.

Surface overflow rate = $\frac{400}{5}$

= 80 g/day/sq. ft.

Settling chamber capacity = 90 gallons

Retention time = $\frac{90 \times 24}{400}$

= 5.4 hours

6. Sludge Return

Sludge return every 12 hours from settling tank to the first aeration compartment, pumping time 3.5 - 5 minutes.

Appendix 2

Waltec Appliance

Aquarobic Unit

Statistical Analysis of Results

From September 5, 1972 to January 10, 1973

loading: 255 US gpd (212 I. gpd)

	IN			OUT 1			OUT 2		
	% of time equal to or less than								
	15%	50%	85%	15%	50%	85%	15%	50%	85%
BOD	124.2	174.7	245.8	10.2	16.1	25.6	0.6	1.8	5.2
Suspended Solids	50.9	101.2	201.2	9.2	19.5	41.2	0.9	3.0	9.5
Volatile Suspended Solids	36.8	79.3	171.0	6.2	13.9	30.9	*0.6	1.6	5.0
Nitrogen as Ammonia	-	-	-	*0.04	0.27	1.9	*0.021	0.12	0.72
Nitrogen as Nitrite	-	-	-	*0.23	0.41	0.74	*0.014	0.06	0.25
Nitrogen as Nitrate	-	-	-	19.7	38.7	76.3	18.1	35.5	69.7
Total Organic Carbon	60.5	88.0	127.8	16.1	21.8	29.4	10.6	14.0	18.5
Soluble Organic Carbon	31.8	45.6	65.5	11.7	15.6	20.8	9.6	12.5	16.3
Phosphate (PO_4)	24.1	31.4	40.8	19.5	25.4	33.1	11.7	17.5	26.1
Total Coliform	-	-	-	*110	1,100	11,100	* 0.022	1.45	93.0
Faecal Coliform	-	-	-	* 0.38	10.0	250.0	* 0.012	0.13	1.4

NB All values, except coliform counts, are in mg/l
Coliform counts are in thousands/~~ml~~ 100 ml.

* values obtained from graphs

Private Waste and Water
Management Branch
Technical Services

Prepared by: Ming. Ng. Cheng
Checked by: ....
Date: ......July 13, 1973

Appendix 2 (cont.)

Waltec Appliance

Aquarobic Unit

Statistical Analysis of Results
From January 11, 1973 to April 28, 1973

loading: 400 US gpd (333 I. gpd)

	IN			OUT 1			OUT 2		
	% of time equal to or less than								
	15%	50%	85%	15%	50%	85%	15%	50%	85%
BOD	102.5	145.3	206.1	19.2	34.5	62.2	1.0	2.3	5.5
Suspended Solids	56.5	92.2	150.3	24.1	55.3	126.9	1.5	4.4	13.1
Volatile Suspended Solids	37.8	68.3	123.3	15.8	40.0	103.5	* 0.3	1.2	5.0
Total Organic Carbon	64.8	84.3	109.8	16.1	23.8	35.2	9.6	12.6	16.6
Soluble Organic Carbon	34.3	45.4	60.0	12.3	14.5	17.0	9.0	10.8	13.0
Nitrogen as Ammonia	16.0	23.3	33.9	*<0.1	0.31	3.0	*<0.1	<0.1	0.44
Total Kjeldahl as Nitrogen	16.4	27.1	44.8	* 1.4	5.4	21.2	* 0.48	0.78	1.3
Nitrogen as Nitrite	0.026	0.1	0.38	* 0.029	0.11	0.43	* 0.012	0.061	0.31
Nitrogen as Nitrate	0.7	1.1	1.8	20.3	24.9	30.5	17.5	22.5	28.9
Phosphate (PO_4)	21.4	27.7	35.9	20.3	26.1	33.6	14.0	18.2	23.5
Total Coliform	*22,000	95,000	420,000	*70	940	13,000	* 0.025	1.1	46.0
Fecal Coliform	* 4,200	11,200	30,000	* 2.0	27.0	370.0	* 0	0.13	4.7

NB All values, except coliform counts, are in mg/1
Coliform counts are in thousands/~~ml~~. 100 ml.

* values obtained by graphical method

Private Waste and Water
Management Branch
Technical Services

Prepared by:

Checked by:

Date: July 10, 1973

AQUAROBIC UNIT

Table of Maximum and Minimum Values in Experimental Data

loading: 255 US gpd (212 I. gpd)

all values except coliform are in mg/1
coliform counts are in thousands/100 ml.

	IN (see sketch A)			OUT 1 (see sketch A)			OUT 2 (see sketch A)		
	Range of Values		No. of Samples Tested	Range of Values		No. of Samples Tested	Range of Values		No. of Samples Tested
	Min.	Max.		Min.	Max.		Min.	Max.	
BOD	52.5	377.0	115	3.5	41.5	98	0.1	29.8	116
Suspended Solids	20.0	740.0	120	0.8	83.0	103	0.4	36.0	121
Volatile Suspended Solids	3.0	650.0	120	0.8	44.4	103	0.	9.6	102
Total Organic Carbon	35.0	207.0	119	12.0	58.0	100	9.0	34.0	120
Soluble Organic Carbon	8.0	102.0	118	10.0	47.0	101	7.0	31.0	119
Nitrogen as NH_3	-	-	-	0	22.2	15	0	3.28	18
Total Kjeldahl as Nitrogen	-	-	-	-	-	-	-	-	-
Nitrogen as Nitrite	-	-	-	0.135	0.927	12	0.009	0.59	13
Nitrogen as Nitrate	-	-	-	4.5	160.0	100	8.8	160.0	118
Phosphate (PO_4)	13.4	109.5	117	8.9	42.5	104	0	26.6	118
Total Coliform	-	-	-	1.7	480,000	15	0	360	15
Faecal Coliform	-	-	-	0.04	20,000	15	0	10	13

Made by........Checked by........Date Feb. 11/73....

AQUAROBIC UNIT

Table of Maximum and Minimum Values in Experimental Date

loading: 400 US gpd (333 I. gpd)

all values except coliform are in mg/l
coliform counts are in thousands/100 ml.

	IN			OUT 1			OUT 2		
	Range of Values		No. of Samples Tested	Range of Values		No. of Samples Tested	Range of Values		No. of Samples Tested
	Min.	Max.		Min.	Max.		Min.	Max.	
BOD	48.0	285.0	92	10.0	298.0	84	0.3	35.0	93
Suspended Solids	32.0	568.0	92	14.0	668.0	84	0.4	86.0	93
Volatile Suspended Solids	11.0	396.0	92	3.6	584.0	84	0	18.0	94
Total Organic Carbon	45.0	125.0	25	13	76	23	9.0	30.0	25
Soluble Organic Carbon	28.0	76.0	26	11	20	23	8.0	15.0	25
Nitrogen as NH_3	13.8	43.2	15	0	9.87	15	0	0.9	15
Total Kjeldahl as Nitrogen	10.6	54.1	14	0	61.3	14	0	1.7	14
Nitrogen as Nitrite	0.024	0.910	14	0.035	0.61	14	0.009	0.96	14
Nitrogen as Nitrate	0.3	8.1	92	15.6	48.6	84	12.2	39.5	92
Phosphate (PO_4)	11.2	51.4	92	17.3	45.7	84	7.2	26.5	93
Total Coliform	11,000	500,000	12	72	20,000	11	0.001	80	12
Faecal Coliform	80.0	30,000	12	0	1,000	12	0	20.0	12

Made by Checked by Date

APPENDIX 4

COMPARISON OF PERFORMANCE OF EXTENDED AERATION PLANTS IN 1971 AND WALTEC AQUAROBIC SYSTEM SEPTEMBER 1972 TO APRIL 1973 - BOD REMOVAL

PROJECT	INFLUENT		PLANT EFFLUENT			REDUCTION %
	NUMBER OF SAMPLES	AVERAGE BOD mg/l	NUMBER OF SAMPLES	AVERAGE BOD mg/l	% OF SAMPLES GREATER THAN 15 mg/l	
Burlington Skyway	26	199	26	8	8	96
Cayuga	2	110	3	3	0	97
Eganville	21	364	11	8	9	98
Elora	52	121	47	32	74	75
Moore Twp.	76	129	76	7	1	94
Moosonee	12	118	12	25	75	79
Paris	15	194	16	12	24	94
Westminster Twp.	23	127	23	11	18	91
Waltec Aquarobic Unit (loading 255 US gpd)	115*	174.7	116*	1.8**	2**	99
Waltec Aquarobic Unit (loading 400 US gpd)	92*	145.3	93*	2.3**	1 **	98

*24 hour composite

all others are eight hour composites

** for Aquarobic unit - Out 2

Private Waste and Water
Management Branch
Technical Services

Prepared by:

Checked by:

Date: July 11, 1973

APPENDIX 5
COMPARISON OF PERFORMANCE OF
EXTENDED AERATION PLANTS IN 1971 AND WALTEC AQUAROBIC SYSTEM
SEPTEMBER 1972 TO APRIL 1973 - SUSPENDED SOLIDS REMOVAL

PROJECT	INFLUENT		PLANT EFFLUENT			REDUCTION %
	NUMBER OF SAMPLES	AVERAGE S.S. mg/l	NUMBER OF SAMPLES	AVERAGE S.S. mg/l	% OF SAMPLES GREATER THAN 15 mg/l	
Burlington Skyway	54	242	48	10	29	96
Cayuga	2	80	3	8	33	90
Eganville	20	392	11	12	18	97
Elora	172	219	200	22	44	90
Moore Twop.	76	129	76	10	16	92
Moosonee	12	108	12	12	58	89
Paris	69	164	180	17	32	90
Westminister Twp.	64	170	23	7	23	96
Waltec Aquarobic Unit (loading 255 US gpd)	120*	101.2	121*	3.0 **	5 **	97
Waltec Aquarobic Unit (loading 400 US gpd)	92*	92.2	93*	4.4 **	11 **	95

*24 hour composite

all others are eight hour composites

** for Aquarobic unit - Out 2

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Checked by:...........................
Date:......July 11, 1973......

APPENDIX 6

COMPARISON OF PERFORMANCE OF EXTENDED AERATION PLANTS IN 1971 AND WALTEC AQUAROBIC SYSTEM SEPTEMBER 1972 TO APRIL 1973 - PHOSPHORUS REMOVAL

PROJECT	INFLUENT		PLANT EFFLUENT		REDUCTION %
	NUMBER OF SAMPLES	AVERAGE PHOSPHORUS (P) mg/l	NUMBER OF SAMPLES	AVERAGE PHOSPHORUS (P) mg/l	
Burlington Skyway	26	9.2	26	4.0	57
Cayuga	2	6.4	2	5.0	22
Eganville	19	12.0	19	7.0	42
Elora	28	11.0	28	6.0	46
Moore Twp.	24	12.0	24	9.0	25
Moosonee	7	6.9	7	4.8	30
Paris	11	8.2	11	6.4	22
Westminster Twp.	12	8.7	12	2.4	72
Waltec Aquarobic Unit (255 US gpd.)	117*	10.5	118*	5.8 **	44
Waltec Aquarobic Unit (400 US gpd.)	92 *	9.2	93*	6.1 **	34

*24 hour composite samples

all others are eight hour composite samples

** for Aquarobic unit - Out 2

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